9. Development of Remedial Action Objectives and Response Actions

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9. DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND RESPONSE ACTIONS

The overall scope and content of the WAG 5 comprehensive feasibility study (FS) report, including assumptions developed to facilitate report preparation, are discussed in this section. The screening and disposition of OU 5-12 sites of concern are discussed in Section 9.1. The assumptions developed for the OU 5-12 FS are listed in Section 9.2. The development of remedial action objectives (RAOs) is presented and the contaminants of concern (COCs), media, exposure pathways of concern, and preliminary remediation goals (PRGs) are identified in Section 9.3. The development of general response actions is presented in Section 9.4. Individual remedial technologies are identified and screened in Section 9.5.

9.1 Introduction

The comprehensive WAG 5 FS addressed the sites forwarded to the FS in Section 8.6 for evaluation of remedial alternatives. The evaluation was developed in accordance with EPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The overall approach is to examine remedial actions that have been evaluated or implemented at the INEEL to define potentially effective and implementable remedial process options for WAG 5 and thus reduce the number of remedial alternatives for detailed analysis.

Sites retained for evaluation in the FS based on carcinogenic human health risks greater than or equal to 1E-04 for one or more exposure scenarios are identified in Table 9-1. The ARA-02 seepage pit sludge and the radiologically contaminated soils at ARA-12, ARA-16, ARA-23, and ARA-25 are the only sites with carcinogenic risks exceeding 1E-04. In addition, the ARA-02 seepage pit sludge is analyzed in the FS based on noncarcinogenic human health issues.

The soil sites retained for evaluation in the FS based on ecological HQs greater than 10.0 are identified in Table 9-2. An HQ of 10.0 was used for screening ecological risk sites to be addressed in the FS based on discussions with DOE-ID, EPA, and IDHW.[a] In addition, those COCs with maximum reported concentrations less than 10 times background concentrations were eliminated from further consideration.

The identification and screening of alternatives focuses on media. Six sites, ARA-01, ARA-12, ARA-16, ARA-23, ARA-25, and PBF-16, contain contaminated soil, and remedial alternatives are analyzed for the combined soils from these sites. Two other sites contain waste and are addressed individually: the ARA-02 seepage pit and the ARA-16 underground storage tank. The ARA-02 seepage pit contains dried sludge and the ARA-16 tank contains liquid waste, both of which are classified as mixed waste. The seven sites addressed in the FS are summarized in Table 9-3, which also indicates whether unacceptable human health or ecological risk is posed by each site.

a. Waste Area Group 5 managers, Lockheed Martin Idaho Technologies Company, July 14, 1998, Conference Call with U.S. Department of Energy, Idaho Operations; U.S. Environmental Protection Agency, Region 10; and Idaho Department of Health and Welfare.

Table 9-1. Sites retained for the feasibility study based on potential future residential human health risks greater than or equal to 1E-04 or a hazard index greater than 2.

Site	Exposure Pathway	Contributing Contaminant of Concern	Half Life (years)	Estimated Excess Cancer Risk	Total Estimated Excess Cancer Risk	Hazard Quotient
ARA-02 ARA-II seepage pit sludge	External exposure	Ra-226	1.60E+03	2E-03		Not applicable
		Cs-137	3.0E+01	7E-05[a]	2E-03	Not applicable
		U-235	7.0E+08	9E-05[a]		Not applicable
		U-238	4.5E+09	3E-05[a]		Not applicable
	Dermal absorption	Aroclor-1242	Not applicable	Not applicable	Not applicable	2
	Ingestion of soil	Aroclor-1242	Not applicable	Not applicable	Not applicable	1
ARA-12 ARA-III leach pond	External exposure	Ag-108m	1.3E+02	2E-03	2E-03	Not applicable
		Cs-137	3.0E+01	2E-04		
ARA-16 ARA-I radionuclide tank soil	External exposure	Cs-137	3.0E+01	1E-04	4E-04[c]	Not applicable
ARA-23 ARA-I and –III soil	External exposure	Cs-137	3.0E+01	5E-04[b]	5E-04	Not applicable
ARA-25 ARA-I contaminated soil beneath the ARA-626 hot cells	External exposure	Cs-137	3.0E+01	2E-03		Not applicable
		Ra-226	1.60E+03	5E-03	8E-03	Not applicable
	Soil ingestion	Arsenic	Not applicable	9E-05		1
		Ra-226	1.60E+03	1E-05		Not applicable
	Dermal absorption	Arsenic	Not applicable	3E-04		2

a. The ARA-02 seepage pit contaminants Cs-137, U-235, and U-238 have a combined risk in excess of 1E-04.

b. The risk estimate for external exposure to Cs-137 is based on in situ gamma survey data and may be underestimated because of the averaging technique used to estimate concentrations.

c. The total risk includes a contribution from Ra-226, which was eliminated from evaluation in the feasibility study. See Section 8.6.

Table 9-2. Sites retained for the feasibility study based on potential ecological risks.

Site	Contaminant of Concern	Hazard Quotient
ARA-01 ARA-I evaporation pond	Selenium	≤ 1 to ≤ 300
	Thallium	≤ 1 to ≤ 300
ARA-12 ARA-III evaporation pond	Copper	≤ 1 to ≤ 300
	Mercury	≤ 1 to ≤ 90
	Selenium	≤ 1 to ≤ 30
ARA-25 ARA-I contaminated soil beneath the ARA-626 hot cells	Copper	≤ 1 to ≤ 40
	Lead	≤ 1 to ≤ 900
PBF-16 SPERT-II leach pond	Mercury	≤ 1 to ≤ 50

Table 9-3. Summary of sites addressed in the feasibility study.

Contaminated Soils	Human Health Site	Ecological Site
ARA-01: evaporation pond		X
ARA-12: radioactive waste leach pond	X	X
ARA-16: soils around the ARA-729 tank	X	
ARA-23: surface soils around ARA-I and II	X	
ARA-25: soils under the ARA-626 hot cells	X	X
PBF-16: SPERT-II leach pond		X
Waste		
ARA-02: seepage pit sludge	X	
ARA-16: waste in tank ARA-729	X	

9.2 Assumptions

The principal assumptions that were incorporated into the development and preparation of the WAG 5 comprehensive FS are listed below:

1. The alternatives previously considered by other INEEL WAGs with similar characteristics are sufficiently representative of remedial alternatives and are adequate to address unacceptable risks posed by WAG 5 sites.

2. Ecological risks will be reduced by remedial actions implemented to reduce human health risks for those sites presenting both types of risks.

3. Preliminary remediation goals (PRGs) based on HQs of 10 or soil concentrations of 10 times background values are protective of ecological receptors.

4. A soil repository called the INEEL CERCLA Disposal Facility (ICDF) will be constructed south of the INTEC and will be operational by 2001. This facility will be permitted to receive any contaminated soil generated on the INEEL, including mixed waste and RCRA waste (24 USC § 9601 et seq.). Disposal capacity for mixed waste will be available at this facility by 2002.

5. Legal issues preventing the disposal of INEEL soils at the Nevada Test Site (NTS) will be resolved by the time waste generated from remediation of WAG 5 requires disposal.

6. The Waste Control Specialists LLC (WCS) facility, located in Andrews County, Texas, will obtain permits to accept low-level and low-level mixed waste for disposal in time to satisfy WAG 5 requirements (see Section 9.5.7.2.3).

7. All soils in WAG 5 except at ARA-25 are not RCRA hazardous waste or TSCA-regulated waste (15 USC § 53).

8. For ARA-25, either a "no longer contained in determination" will be obtained or the soils will be delisted in the WAG 5 ROD. (Note: Soil within the ARA-25 site was originally considered RCRA F-listed waste because the site is associated with ARA-16, the radionuclide tank that contains waste identified as RCRA F-listed waste because of the presence of trichloroethylene. However, trichloroethylene was not detected in analysis of the ARA-25 soils.)

9. The ARA-02 seepage pit sludge, concrete blocks of the seepage pit, and associated piping are not regulated for polychlorinated biphenyls (PCBs) by TSCA. (Two approaches will be examined if subsequent waste characterization identifies the waste as TSCA-regulated waste. Either a stabilization process will be considered and an ARAR waiver will be pursued in the ROD to allow on-Site or off-Site disposal or a solvent extraction process to remove PCBs will be investigated that will allow disposal of the waste forms in a TSCA-permitted facility.)

10. The ARA-16 stainless steel tank and associated piping can be decontaminated and disposed of as non-RCRA, non-TSCA, low-level waste.

11. The INEEL-wide monitoring programs for air and groundwater will be adequate for all alternatives leaving contamination in place because the BRA (see Section 6.4.2) did not identify risks from groundwater or air pathways in excess of 1E-04 at WAG 5.

9.3 Remedial Action Objectives

Remedial action objectives (RAOs) for WAG 5 were developed in accordance with the National Oil and Hazardous Substances Contingency Plan (NCP) (40 CFR 300), and EPA guidance (EPA 1988) and through the consensus of DOE-ID, EPA, and IDHW participants. The RAOs are based on the results of both the human health and ecological risk assessments and are specific to the COCs and exposure pathways developed for WAG 5.

The conclusions from the RI/BRA used to develop RAOs are summarized below:

- External exposure, ingestion of homegrown produce, and ingestion of soil are the only human health exposure routes with unacceptable estimated risks for soils and the ARA-02 seepage pit sludge.

- Potential groundwater impacts from the simulated infiltration of COCs from WAG 5 do not result in risks greater than 1E-04 for groundwater pathways. In addition, groundwater modeling indicates a hazard index < 1.0 and all groundwater pathway contaminants of concern are predicted to remain at concentrations less than maximum contaminant levels. Hence, an RAO for groundwater is not necessary.

- Risks associated with the air pathway are well below 1E-04. Therefore, RAOs for the air pathway are not required. (Note: Appropriate safety measures, as determined by air emissions calculations, will be implemented during remedial actions to ensure that dust emissions do not exceed the limits specified by ARARs.)

- The ARA-16 waste tank contents were excluded from quantitative analysis in the BRA. However, the contaminants present in the tank waste probably would result in unacceptable risk if they were released to the environment (see Section 6.5). Therefore, an RAO for the tank contents was developed.

The RAOs specified for protecting human health are expressed both in terms of risk and exposure pathways because protection can be achieved through reducing contaminant levels as well as through restricting or eliminating exposure pathways. The overall intent of the human health RAOs is to limit the cumulative human health risk to less than or equal to 1E-04. The RAOs specified for protecting ecological receptors inhibit adverse effects from contaminated soil and tank contents on resident populations of flora and fauna.

The RAOs developed for WAG 5 to protect human health and ecological receptors are as follows:

- Inhibit direct exposure to radionuclide COCs at any WAG 5 site or combination of sites that would result in a total excess cancer risk of 1E-04 or greater for current and future workers and future residents.

- Prevent release of, and human and ecological exposures to, ARA-16 tank contents

- Inhibit ecological receptor exposures to contaminated soil with concentrations greater than or equal to 10 times background values and that result in an HQ greater than or equal to

10.0. The RAO excludes naturally occurring elements and compounds that are not attributable to WAG 5 releases.

9.3.1 Contaminants and Sites of Concern

The contaminants that contribute to human health risks, listed in Table 9-1, were evaluated in the FS. Of all the potential contaminants that were analyzed, only four were determined in the human health risk assessment to have excess cancer risks greater than 1E-04: Ag-108m at ARA-12; Cs-137 at ARA-12, ARA-16 (soil), ARA-23, and ARA-25; Ra-226 at ARA-25 and in the ARA-02 seepage pit sludge; and arsenic at ARA-25. In addition, because the combined total risk for Cs-137, U-235, and U-238 in ARA-02 seepage pit sludge is 2E-04, these contaminants also are identified as COCs and were included in the FS evaluation for this site.

The COCs for WAG 5 sites retained based on ecological risks are shown in Table 9-2. All of the ecological COCs are inorganic.

9.3.2 Media of Concern

Media of concern for WAG 5 sites consist of contaminated soils and tank waste. In addition, minor amounts of debris are associated with the ARA-02 seepage pit and ARA-16 waste tank. The debris includes the pumice blocks compose the seepage pit and the concrete vault, stainless steel tank, and piping of the ARA-16 tank system.

All the soils, with the exception of PBF-16, are contaminated with low levels of radionuclides, and except for ARA-16 and ARA-23, the soils also are contaminated with low concentrations of toxic metals. Based on available data, which include total analysis for organics and heavy metals and TCLP test results, none of the soils, except that in ARA-25, are identified as TSCA-regulated or RCRA-hazardous waste. The soils at ARA-25 are considered RCRA F-listed waste for tetrachloroethylene because the site is associated with ARA-16. However, total analysis of tetrachloroethylene in ARA-25 soil shows concentrations are below detection limits. As indicated in Section 9.2, it is assumed that either a "no longer contained in" determination will be obtained for ARA-25 or ARA-25 soils will be delisted in the WAG 5 ROD. Analyses of the soils around the ARA-02 seepage pit and ARA-16 tank indicate that the wastes in the seepage pit and tank have not been released to the environment. The chemical and radiological characteristics of the ARA-02 seepage pit sludge and the ARA-16 tank waste are shown in Tables 9-4 and 9-5. A summary of the maximum dimensions of the contaminated soil sites and the waste volumes contained in ARA-02 and ARA-16 is provided in Table 9-6.

9.3.3 Exposure Scenarios and Pathways of Concern

Exposure scenarios and pathways of concern for human health are identified in Table 9-1. As shown in the table, excess cancer risk for only three pathways, external radiation exposure, dermal absorption, and soil ingestion, exceeds 1E-04. The external radiation risk exceeds 1E-04 for the radionuclides Ag-108m, Cs-137, and Ra-226, and the dermal absorption pathway exceeds 1E-04 for arsenic. In addition, the combined external exposure risk exceeds 1E-04 for Cs-137, U-235, and U-238 in the seepage pit sludge, and the combined soil ingestion risk exceeds 1E-04 for arsenic and Ra-226 for ARA-25.

The exposure pathways of concern for the ecological receptors are ingestion of contaminated vegetation and incidental ingestion of soil.

Table 9-4. Chemical and radiological characteristics of the ARA-02 seepage pit sludge.

Contaminant		Minimum Concentration	Maximum Concentration	Average Concentration
Cyanide (total) (mg/kg)		1.3	1.3	1.3
Metals (mg/kg)	Aluminum	6,500	16,000	8,686
	Arsenic	14	35	23
	Barium	120	210	139
	Beryllium	0.13	0.59	0.23
	Cadmium	12	26	21
	Chromium	530	1,100	949
	Copper	370	800	656
	Iron	7,700	15,000	9,386
	Lead	140	310	251
	Lithium	1.1	9.5	2.9
	Magnesium	950	4,600	1,687
	Manganese	59	250	102
	Mercury	2.2	3.7	3.2
	Nickel	750	1,700	1364
	Phosphorus	1,500	2,700	2,186
	Selenium	7.9	18	11.3
	Silver	140	300	237
	Sodium	220	510	286
	Titanium	150	650	267
	Zinc	560	1100	941
PCBs (mg/kg)	Aroclor-1242	6.9	23.5	12.88
Radionuclides (pCi/g)	Gross alpha	762	1,420	1,080
	Gross beta	59.5	212	136
	Ag-108m	0.23	0.23	0.23
	Co-60	33.7	87.4	63.1
	Cs-134	0.404	0.404	0.404
	Cs-137	61.6	178	118.8
	Eu-152	2.59	35.2	9.47
	Eu-154	0.487	2.27	1.019
	Nb-95	0.145	0.272	0.209
	Ra-226	32.9	89.6	63.2

Table 9-4. (continued).

Contaminant		Minimum Concentration	Maximum Concentration	Average Concentration
	U-235	37.3	79.3	60.9
	Np-237	0.0738	0.712	0.313
	Pu-238	0.16	0.375	0.244
	Pu-239/240	0.977	1.5	1.24
	Tc-99	20.1	63.9	39.2
	Th-228	0.588	0.757	0.669
	Th-230	0.359	4.5	1.608
	Th-232	0.428	0.529	0.472
	Th-234	66.9	142	111.8
	U-234	77.9	1,250	822.0
	U-235	4.78	120	59.6
	U-238	6.01	112	70.0
SVOCs (µg/kg)	Di-n-butylphthalate	110,000	160,000	138,333
	Bis(2-ethylhexyl)phthalate	3,700	9,500	7,571
	4-Chloroaniline	4,500	6,400	5,700
	Methyl methacrylate	13,000	16,000	14,500
TCLP metals (µg/L)	Arsenic	38.6	38.6	38.6
	Barium	494	549	522
	Cadmium	694	750	722
	Chromium	35.9	36.6	36.3
	Lead	476	482	479
	Silver	1.4	2.3	1.9
VOCs (µg/kg)	Methylene chloride	50	270	177
	1,1,1-Trichloroethane	5	13	10
	Trichloroethene	4	7	5
	Tetrachloroethene	4	16	10
	Toluene	4	62	34
	Xylene (total)	3	34	22
	Acetone	52	52	52
	Ethylbenzene	3	8	6
	Trichlorofluoromethane	2	11	8
	Diethylether	32	41	37

Table 9-5. Chemical and radiological characteristics of the ARA-16 tank contents.

Contaminant	Liquid Phase Minimum Concentration	Liquid Phase Maximum Concentration	Sludge Phase Minimum Concentration	Sludge Phase Maximum Concentration
Anions (mg/L)				
Fluoride	0.826	1.91		34.3
Chloride	200	236		1,660
Bromide	0.348	0.385		
Nitrate				11.7
Phosphate	110	112		1,050
Sulfate	93.9	105		581
Cyanide (mg/L)				
Total	0.011	0.012		15.8
Metals	(µg/L)	(µg/L)	Dry / Wet (mg/kg)	Dry / Wet (mg/kg)
Aluminum	275	340.1	11,300 / 2,360	17,100 / 3,570
Antimony			11.8 / 2.48	12.1 / 2.52
Arsenic	13.4	14.1	1,180 / 0.766	2,650 / 0.760
Metals	(µg/L)	(µg/L)	Dry / Wet (mg/kg)	Dry / Wet (mg/kg)
Barium	1.6	4.6	215 / 44.9	329 / 68.8
Beryllium	0.3	0.3	5.58 / 1.17	9.58 / 2.00
Cadmium			28.5 / 5.97	16.7 / 3.50
Calcium	9,100	9,760	7,800 / 1630	11,500 / 2,390
Chromium	5.9	22.6	878 / 184	1,370 / 287
Cobalt			6.66 / 1.39	17.9 / 3.74
Copper	169	179.8	393 / 82.1	660 / 138
Iron	152	193	22,500 / 4,700	47,000 / 9,820
Lead	14.9	36.2	2,600 / 543	3,970 / 830
Magnesium	25,700	27,300	3,650 / 762	5,560 / 1,160
Manganese	7.4	7.4	103 / 21.4	216 / 45.1
Mercury	0.42	0.6	2.07 / 0.434	3.35 / 0.700
Nickel	139	147	190 / 39.8	407 / 85.0
Potassium	13,800	14,800	1,450 / 304	2,280 / 477
Selenium			4.400 / 0.919	5,270 / 1.10

Table 9-5. (continued).

Contaminant	Liquid Phase Minimum Concentration	Liquid Phase Maximum Concentration	Sludge Phase Minimum Concentration	Sludge Phase Maximum Concentration
	(µg/L)	(µg/L)	Dry / Wet (mg/kg)	Dry / Wet (mg/kg)
Silver	18.3	31.1	527 / 110	720 / 151
Sodium	243,000	253,000	3,000 / 628	4,390 / 917
Sulfur			2,040 / 427	3,960 / 827
Thallium			279 / 0.058	308 / 0.064
Vanadium	9.9	11.2	84.4 / 17.6	159 / 33.3
Zinc	46.9	56.9	586 / 123	890 / 186
PCBs	(µg/L)	(µg/L)	(µg/kg)	(µg/kg)
Aroclor-1260			52,000	98,000
Radionuclides	(pCi/L)	(pCi/L)	(pCi/g)	(pCi/g)
Ag-108m			2,480	6,800
Co-60	16,700	18,700	105,000	320,000
Cs-134	199,000	213,000	24,700	38,300
Cs-137	58,500,000	60,900,000	9,190,000	13,300,000
Eu-152			16,100	24,900
Eu-154			4,160	9,080
Zn-65			4,910	6,560
Pu-238	874	1,290	14,800	28,700
Pu-239/240	1,230	2,150	15,900	28,000
U-234	698	798	31,400	38,900
U-235		4.68		
U-238	15	16		464
Am-241	1,450	1,900	25,900	36,400
Strontium-90 (pCi/g)	162,000	172,000	455,000	638,000
Tritium (pCi/g)	290,000	301,000		
TCLP VOCs	(µg/L)	(µg/L)	(µg/kg)	(µg/kg)
1,1-Dichloroethene				550
Trichloroethene				40,000
VOCs	(µg/L)	(µg/L)	(µg/kg)	(µg/kg)
1,1-Dichloroethene		190		46,000

Table 9-5. (continued).

Contaminant	Liquid Phase Minimum Concentration	Liquid Phase Maximum Concentration	Sludge Phase Minimum Concentration	Sludge Phase Maximum Concentration
	(μg/L)	(μg/L)	(μg/kg)	(μg/kg)
Trans-1,2-dichloroethene		7		
1,1-Dichloroethane		360		8,300
Cis-1,2-dichloroethene		53		1,300
1,1,1-Trichloroethane	60,000	63,000	19,000,000	22,000,000
Trichloroethene	13,000	13,000	3,600,000	4,500,000
Toluene		28	160,000	210,000
1,1,2-Trichloroethane		110		2,800
Tetrachloroethene		5		7,800
Ethylbenzene				4,600
M- and P-xylenes				19,000
O-xylene				6,100
1,1,2,2-Tetrachloroethane		43		3,900

Table 9-6. Areas, depths, and volumes of contaminated media for WAG 5 sites.

Site	Site Name	Soil Area (ft^2)	Depth (ft)	Soil Volume (ft^3)	Waste Volume (gal)
ARA-01	ARA-I Chemical Evaporation Pond	32,155	2	64,310	NA
ARA-02	ARA-I Seepage Pit (sludge)	NA[a]	NA	NA	380
ARA-12	ARA-III Radioactive Waste Leach Pond	2,337	1	2,377	NA
ARA-12	ARA-III Cs-137 Contaminated Soil Southwest of ARA-12	43,278	0.5	21.640	NA
ARA-16	ARA-I Radionuclide Tank Soils	350	5	1755	NA
ARA-16	ARA-I Radionuclide Tank Waste	NA	NA	NA	29
ARA-23	ARA-I and –II Radiologically Contaminated Surface Soils and Subsurface Structures	2,510,000	0.5	1,255,000	NA
ARA-25	ARA-I Contaminated Soils Below ARA-626 Hot Cells	384	5	1,920	NA
PBF-16	SPERT-II Leach Pond	3,000	4.5	13,500	NA

a. NA means not applicable.

9.3.4 Preliminary Remediation Goals

Preliminary remediation goals are quantitative cleanup levels used to plan remedial actions and assess the effectiveness of remedial alternatives. Final remediation goals are based on the results of the BRA, ARARs, and the evaluation of expected exposures and risks for alternatives. The effects of multiple contaminants also are taken into consideration. Final remediation goals will be presented in the WAG 5 ROD.

Typically, PRGs to address human health are based on media-specific COC concentrations associated with an excess cancer risk of 1E-04 or an HI of 1.0, whichever is more restrictive. For WAG 5, the PRGs for individual COCs were defined by calculating contaminant concentrations in soil that would result in an excess cumulative cancer risk of 1E-04 to hypothetical residents at the end of the 100-year institutional control period. A given COC may have different PRG values at different sites because some sites have multiple COCs affecting the same exposure pathway. For example, if a given site only has one contaminant requiring remediation, the PRG for the contaminant would equal the contaminant concentration equivalent to a risk of 1E-04. If, however, the site has two contaminants requiring remediation, the PRG for each contaminant would equal one-half of the concentration associated with an excess risk of 1E-04 (i.e., risk of 5E-05) for each contaminant, so that the total risk for the site would be limited to 1E-04.

The PRGs to address ecological risks are based on soil concentrations associated with either an HQ equal to 10 or 10 times the background value, whichever is less. Sites with ecological HQs between 1 and 10 will be addressed in the Site-wide ecological risk assessment under OU 10-04. Table 9-7 provides the human health and ecological PRGs for WAG 5.

9.4 General Response Actions

General response actions (GRAs), which are broad categories of remedial actions to satisfy RAOs, were identified for the environmental media associated with WAG 5 sites. To protect human health and the environment, the intent of GRAs is to eliminate source-to-receptor pathways by preventing the exposure of a receptor to contaminants and reducing or eliminating contaminant migration to clean media.

General response actions, individually or in combination, can satisfy RAOs in one of two ways: (1) contaminants can be destroyed or reduced in concentration or (2) contaminants can be isolated from potential exposure and migration pathways. Contaminant destruction is the preferred method because it ensures that the RAOs have been satisfied. However, radionuclide contamination within WAG 5 sites cannot be destroyed and, therefore, must be isolated from potential exposure and migration pathways.

A range of GRAs and a combination of GRAs that could achieve varying degrees of protectiveness of human health and the environment and compliance with RAOs have been defined. Six GRAs and combinations of GRAs were identified for WAG 5:

- No action
- Institutional controls
- Consolidation, containment, and institutional controls
- In situ treatment

Table 9-7. Preliminary remediation goals.

Site	Human Health		Ecological		Range of Detected COC Concentrations at Site (mg/kg or pCi/g)	
	Contaminant of Concern	Preliminary Remediation Goal (pCi/g or mg/kg)	Contaminant of Concern	Preliminary Remediation Goal (mg/kg)	Minimum Concentration	Maximum Concentration
ARA-01 ARA-I evaporation pond	—[a]	—	Selenium	2.2	0.15	27.7
	—	—	Thallium	4.3	1	59.2
ARA-02 ARA-II seepage pit sludge	Aroclor-1242	5	—	—	6.9	23.46
	Ra-226	2.2	—	—	32.9	89.6
	Cs-137	23 or 7.7[b]	—	—	61.6	178
	U-235	13 or 4.3[b]	—	—	7.78	120
	U-238	67 or 22[b]	—	—	6.01	112
ARA-12 ARA-III leach pond	Ag-108m	1.2	—	—	0.23	67.2
	Cs-137	23	—	—	0.1	4.42
	—	—	Copper	220	12.2	623
	—	—	Mercury	0.5	0.15	1.4
	—	—	Selenium	2.2	0.21	2.7
ARA-16 ARA-I radionuclide tank soil	Cs-137	23	—	—	0.27	201
ARA-23 ARA-I and -II soil	Cs-137	23	—	—	0.08	2140
ARA-25 ARA-I soil under ARA-626 hot cells	Arsenic	10				
	Cs-137	23				
	Ra-226	2.2				
			Copper	220		
			Lead	170		
PBF-16 SPERT-II leach pond	—	—	Mercury	0.5	0	0.71

a. Not applicable.

b. The combined risk for the three contaminants of concern at ARA-02 must be limited to 1E-04. The concentrations shown indicate the contaminant-specific preliminary remediation goal that would apply if no other contaminant were present, followed by the concentration equivalent to one-third of the 1E-04 risk-based concentrations.

- Removal, ex situ treatment, and disposal
- Removal and disposal.

A description of each GRA identified for the WAG 5 sites is presented below.

9.4.1 No Action

A "no action" GRA does not involve active remedial actions with the exception of environmental monitoring. Monitoring is included to enable identification of potential contaminant migration or other changes in site conditions that may warrant future remedial actions. Types of environmental monitoring considered for use at WAG 5 sites are defined in the description of alternatives presented in Section 10. Monitoring is an institutional control action that can be assumed to remain in effect for at least 100 years. Though the no action GRA may not achieve RAOs established for WAG 5, it is retained to serve as a baseline for evaluating remedial action measures.

9.4.2 Institutional Controls

Institutional controls are limited actions taken by the responsible authorities to minimize potential danger to human health and the environment. Institutional controls are ongoing actions that can be maintained only as long as the responsible authority is in control of the site. Based on DOE Order 5820.2A, "Radioactive Waste Management," active institutional control of low-level radioactive waste disposal sites is required for a minimum of 100 years following closure. To remain consistent with the BRA, the 100-year institutional control period is assumed to begin in 1998 and end in 2098.

The institutional control measures included in this GRA are long-term environmental monitoring as described for the no action alternative; access restrictions including fencing, legal restrictions (e.g., deed restrictions), and other measures; and water diversion. The institutional control measures would be established and maintained as necessary where contamination remains in place to provide early detection of potential contaminant migration and to control exposures to contaminants. The effectiveness of these institutional controls would be evaluated by DOE-ID, EPA, and IDHW during subsequent 5-year reviews.

9.4.3 Consolidation, Containment, and Institutional Controls

A combination of containment and institutional controls is one GRA for WAG 5. Potential containment strategies are limited to physical measures, such as capping with a soil cover or engineered barrier, to reduce or eliminate direct human contact with the contaminated material, minimize contaminant mobility, and protect the environment. Containment does not reduce the volume or toxicity of the contaminated media. Because of the number of contaminated sites, the large areas of some of the sites, and the shallow depth of contamination, the practical implementation of containment at WAG 5 requires consolidation of contaminated materials at a central location. The institutional controls that can be used in conjunction with containment are described in Section 9.4.2

9.4.4 In Situ Treatment

In situ treatment technologies include physical, chemical, biological, and thermal treatment methods. The contaminated media are treated in place, without excavation. The treatments reduce the toxicity, mobility, or volume of the contaminated material by altering the physical or chemical properties to achieve degradation, fixation, or destruction of contaminants. While the waste volume may increase or decrease depending on the in situ treatment method, nonradioactive contaminant mobility and toxicity may be reduced or eliminated through treatment to prevent exposures. Though no method exists for destroying or reducing the toxicity of radionuclides, the mobility of radioactive contaminants also can be diminished.

9.4.5 Removal

Removal technologies include the conventional or remote excavation and handling of contaminated material or structures in preparation for subsequent treatment, storage, or disposal. Another removal technology, soil vacuuming, uses a high-volume, high-vacuum, truck-mounted system to remove surface contaminated soils.

9.4.6 Ex Situ Treatment

Ex situ treatment technologies include physical, chemical, biological, and thermal treatment methods that reduce the toxicity, mobility, or volume of a contaminant by altering its physical or chemical properties. The impacted media are conventionally or remotely excavated and handled before treatment. Remotely handled material may require remote treatment. While the waste volume may increase or decrease depending on the ex situ treatment method, contaminant mobility or toxicity may be reduced or eliminated through treatment. Exposure routes are generally eliminated once the media are excavated and removed.

9.4.7 Disposal

Disposal involves the placement of excavated material in an on-Site or off-Site permanent engineered waste management facility to restrict contaminant mobility and mitigate exposure routes. However, in some cases, excavated material may be stored in an engineered waste management facility for an interim period of time while awaiting shipment to a permanent disposal facility.

9.5 Identification and Screening of Technologies

The identification and preliminary screening of potentially applicable remedial technologies and process options for WAG 5 sites are described in this section. Remedial technology types and process options were identified and screened based on effectiveness, implementability, and cost. Both conventional and innovative and emerging technologies that have been demonstrated at a pilot scale are considered in this evaluation. The detailed evaluation of the screening criteria for each of the alternatives is found in Sections 9.5.1 through 9.5.7. The identification and screening for the remedial technologies considered for WAG 5 sites are shown in Table 9-8.

To evaluate effectiveness, the ability of each technology or process option to remediate the waste media and meet the RAOs was considered. Specific information considered includes the ability of the technology to handle the types and volumes of contaminated media, proven reliability of the technology relative to contaminants and conditions at the sites, and the potential impacts to human health and the environment during implementation. The effectiveness of each option was classified as high, moderate, low, or uncertain in Table 9-8.

To evaluate implementability, the technical and administrative feasibility of each technology was considered. Technical implementability refers to technology-specific parameters that constrain effective construction and operation of the technology relative to site-specific conditions. Administrative implementability refers to the capability to obtain required permits for on- and off-Site actions; the availability of treatment, storage and disposal services; and the availability of equipment and personnel required for implementing the technology. The implementability of each option was classified as high, moderate, low, or uncertain in Table 9-8.

Table 9-8. Screening of remedial technologies.

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
No action	Environmental monitoring	Groundwater sampling	Not applicable	High	Moderate	Retain
		Vadose zone monitoring	Not applicable	High	Moderate	Retain
		Air sampling	Not applicable	High	Low	Retain
		Soil surveys	Not applicable	High	Low	Retain
Institutional controls	Access restrictions	Fences	High for institutional control period only and for human health risk reduction only	High for institutional control period only	Low	Retain
		Deed restriction	High for institutional control period only and for human health risk reduction only	High, for institutional control period only, uncertain afterward	Low	Retain
Consolidation, containment and institutional controls	Cap	Native soil cover	Moderate	High	Moderate	Retain
		Engineered barrier	Moderate	High	Moderate	Retain
	Maintenance	Cap integrity monitoring and maintenance	High during institutional control period	High during institutional control period	Moderate	Retain
In situ treatment	Thermal	Vitrification	High for tank waste, low for soils; no reduction in direct radiation exposure risks	Low for soils, moderate for the ARA-16 tank and ARA-02 seepage pit	High	Retain for tank waste Reject for soils
	Physical and chemical	Stabilization or solidification	Moderate for ARA-02 seepage pit sludge	Moderate for ARA-02 seepage pit sludge	High	Retain for ARA-02 seepage pit sludge
			Low for ARA-16 tank waste and soils	Low for ARA-16 tank waste and soils		Reject for ARA-16 tank waste and soils
	Chemical	Soil flushing	Low	Low	High	Reject

Table 9-8. (continued).

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
		Chemical leaching	Low	Low	Moderate	Reject
		Oxidation/reduction	Low	Low	High	Reject
	Biological	Phytoremediation	Uncertain, currently undergoing testing at ANL-W	Uncertain	Low	Reject
Removal and disposal	Standard techniques	Excavation with conventional earth-moving equipment	High	High	Low	Retain
		Truck-mounted vacuum systems	High	High	Low	Retain
	Remote techniques	Robotics	Low	Low	High	Reject
Ex situ treatment	Physical separation	Screening	Low	High	Low	Reject
		Flotation	Low	High	Low	Reject
		Attrition scrubbing	Low	Moderate	Moderate	Reject
		Gamma monitor, conveyer, and gate system	Uncertain pending site demonstration	Moderate	Moderate	Retain
	Thermal treatment	Incineration	Low for soils High for sludge	High	Moderate	Reject for soil Retain for sludge
	Chemical treatment	Fixation and stabilization	Low for soil High for tank waste and sludge	Moderate	Moderate	Reject for soil Retain for tank waste and sludge
		Soil washing	Low	Low	Moderate	Reject
Disposal	Landfilling radiologically contaminated soil and debris on the INEEL	RWMC	High	High, though disposal of low-level radiologically contaminated soil is currently discouraged	High	Retain
		WWP	High	Low	Low	Reject

Table 9-8. (continued).

General Response Action	Remedial Technology	Technology Options	Effectiveness	Implementability	Relative Cost	Screening Result
		INEEL CERCLA Disposal Facility (ICDF)	High, though status is uncertain	Status uncertain – currently projected to be available in 2001 for LLW soil and debris	Low	Retain
		WAG 5 soil consolidation	High	High, though public acceptance is uncertain	Low	Retain
	Landfilling nonradiologically contaminated soil and debris that are not RCRA- or TSCA-regulated on the INEEL	CFA Landfill	High	High	Low	Retain
	Disposal of mixed low-level waste and radiologically contaminated soil off the INEEL	Nevada Test Site	High	Uncertain; INEEL is not yet an approved generator	Not yet determined, but assumed to be high	Retain
		Envirocare	High	High	Moderate	Retain
		Waste Control Specialists	High	Uncertain	Moderate	Retain

Relative costs were evaluated by comparing relative estimates of capital, operation, and maintenance costs. Engineering judgment was used to classify costs as high, moderate, or low, relative to other process options in the same technology type for each medium of concern.

9.5.1 No Action

Active remediation is not conducted under the No Action option. Environmental monitoring is the only activity considered for the No Action alternative. While the No Action GRA would not achieve RAOs established for WAG 5, it is retained to serve as a baseline for evaluating other remedial action alternatives.

Monitoring would include annual leak testing and vadose zone monitoring of the ARA-16 tank, and groundwater, air, and soil monitoring for all sites. Groundwater monitoring would be implemented through an INEEL-wide program. Air monitoring may include particulate monitors to determine whether fugitive radionuclides escape from sites at which contaminated soil and debris are left in place. Air monitoring also would be implemented through an INEEL-wide program. Soil monitoring may include radiation surveys over and around sites where contaminated soil and debris are left in place to determine whether radionuclides or toxic metals are mobilized to the surface.

Potentially, all of these monitoring technologies would be technically and administratively implementable. Costs of soil and air monitoring would be low, while groundwater monitoring costs would be moderate. All monitoring technologies shown in Table 9-8 pass the screening process and were considered further in the FS.

9.5.2 Institutional Controls

Institutional controls alone may meet human health RAOs during the institutional control period and longer in combination with other technologies and GRAs. Institutional controls may include legal access restrictions (i.e., deed restrictions), and physical access restrictions (e.g., fencing). These controls are considered for all WAG 5 sites of concern.

9.5.2.1 Deed Restrictions. A deed is a legally binding deed notice that limits the use of land at a given site. These restrictions prevent the completion of exposure pathways that would result in an unacceptable risk to human health, but are not effective in reducing ecological exposures.

Deed restrictions are effective and implementable only for the period of institutional control. Costs are relatively low. Deed restrictions were retained for further evaluation in the FS.

9.5.2.2 Access Restrictions. Access restrictions, such as fences, are to be maintained for at least the 100-year institutional control period following site closure. This institutional control reduces risks to human health by limiting exposure to contaminated media but are generally not effective in reducing ecological exposure. It is a viable technology for contamination that is not likely to become airborne. Signs are typically placed at the site to indicate restricted access.

This option is effective and readily implementable, with relatively low costs. Fencing has been retained for further evaluation in the FS.

9.5.3 Consolidation, Containment, and Institutional Controls

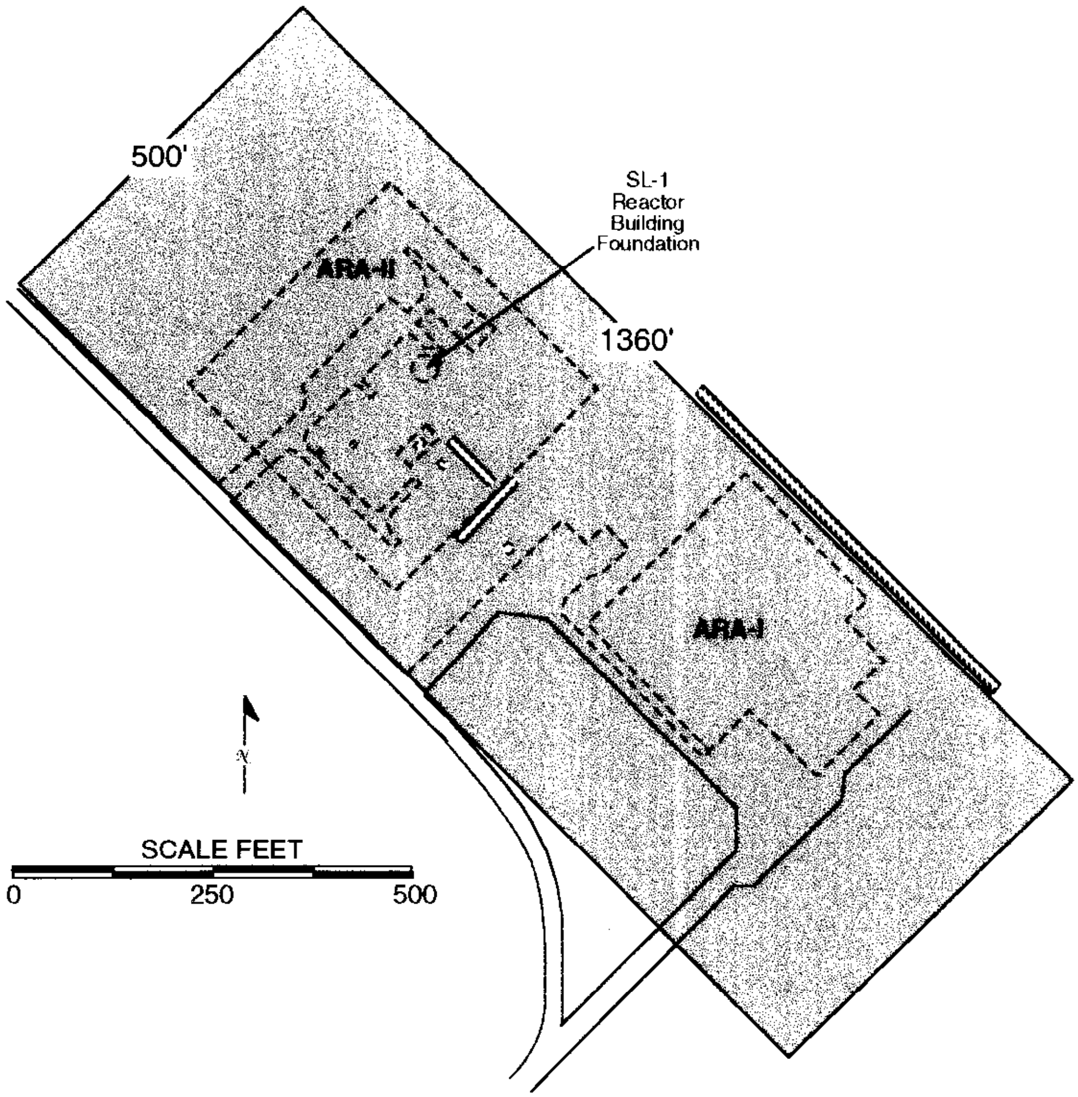
Containment refers to remedial actions taken to isolate contamination from the environment. Isolation of contamination eliminates potential exposure pathways to human receptors. Containment technologies evaluated under this GRA are native soil covers and engineered barriers, and would apply to radiological and nonradiological contaminated soil. Because of the number of contaminated soil sites, the large areas of some of the sites such as ARA-23, and the shallow depth of contamination, practical implementation at WAG 5 requires excavation and consolidation of contaminated soil at a central location. Without consolidation of soils, numerous containment structures would have to be constructed, and some of these would be very large.

To assess the potential impacts to groundwater associated with consolidating the contaminated soils, a supplemental risk analysis was performed. The supplemental analysis is conservative because it does not simulate the protection of an engineered barrier. Furthermore, the same conservative parameters applied in the BRA were implemented. Source terms for arsenic, copper, mercury, selenium, thallium, Ag-108m, Cs-137, and Ra-226 for the WAG 5 consolidation were calculated using the density of soil, mass of contaminant, volume of site, and UCL or maximum detected concentrations. The volume for each site and the total consolidated volume are shown in Figure 9-1. The masses of the contaminants were calculated using site volumes and a soil density of 1.5 g/cm^3. The 95% UCLs were taken from Figures 8-1 through 8-7 and were used along with the masses to calculate the consolidated source term inventories. Because several contaminants were found at various sites, the source terms from the multiple sites were summed to obtain a total source term. The dimensions used for the hypothetical consolidation site in the GWSCREEN analysis are 1,360 × 500 × 2 ft. The maximum groundwater concentrations were calculated by GWSCREEN and used to develop the intake factors from the ingestion of groundwater, which was then used to evaluate risk. A summary of the groundwater ingestion risks associated with a hypothetical consolidation site at ARA-I assuming maximum groundwater concentrations and no barrier is given in Table 9-9. A hypothetical location over the contaminated ARA-I and ARA-II facilities is shown in Figure 9-1. However, several locations within WAG 5 are probably suitable soil consolidation sites.

9.5.3.1 Native Soil Cover. This cover type consists of approximately 3.05 m (10 ft) of native INEEL soil (i.e., the assumed residential receptor exposure depth) compacted in lifts and covered with vegetation, gravel, riprap, or other media. This design is effective in controlling surface exposures but may not be as effective in inhibiting infiltration or biointrusion as an engineered cover. Impacts to human health and the environment could likely be minimized to allowable levels through the use of administrative and engineering controls such as periodic inspections and repairs. The cost of this type of cover is moderate. The native soil cover is retained for further consideration.

9.5.3.2 Engineered Barriers. Two types of engineered barriers were considered: a capillary barrier/biobarrier cover and the SL-1 type cap.

9.5.3.2.1 Capillary Barrier/Biobarrier Cover—This technology would be highly effective in protecting human health and the environment and meeting RAOs for WAG 5 at least through the period of institutional control. The capillary barrier/biobarrier cover consists of layers of fine-grained earthen materials overlying coarse-grained media. The large variation in soil moisture tension between the two layers results in infiltrating water being retained in the upper, fine-grained layers by capillary attraction, within the root zone of surficial vegetation, until saturated. Evaporation and plant transpiration can remove essentially all precipitation that falls in arid regions, including the INEEL high desert environment (Anderson et al. 1992), typically preventing development of saturated conditions and preventing drainage through the capillary barrier (Keck et al. 1992). A base course of asphalt or concrete may be used to further limit infiltration. The capillary break also would serve as a biobarrier, inhibiting biointrusion, or, alternatively, a separate layer can be used for this function. A conceptual drawing of a capillary barrier/biobarrier cover is given in Figure 9-2.



Release Site	Site Name	Volume (yd^3)	Volume (m^3)
ARA-01	ARA-I Chemical Evaporation Pond	2,400	1824
ARA-12	ARA-III Radioactive Waste Leach Pond	90	68
ARA-12	ARA-III Cs-137 Contaminated Soil Southwest of ARA-12	800	608
ARA-16	ARA-I Radionuclide Tank Soils	65	49
ARA-23	ARA-I and -II Radiologically Contaminated Surface Soils	46,500	35,340
ARA-25	ARA-I Soils Beneath the ARA-626 Hot Cells	70	53
PBF-16	SPERT-II Leach Pond	500	380
Approximate total		5.0E+04	3.8E+04

Figure 9-1. Hypothetical consolidation site in Waste Area Group 5 for contaminated soils.

Table 9-9. Potential groundwater concentrations and groundwater ingestion risks associated with the hypothetical consolidation of contaminated soils with no cover within WAG 5.

Contaminant	Maximum Potential Groundwater Concentration (pCi/L or mg/L)	Human Health Risk	Human Health Hazard Quotient	Time of Peak Concentration (year)
Arsenic	1.92E-04	4.1E-06	1.7E-02	5.99E+01
Copper	1.00E-03	—	7.4E-04	2.62E+02
Lead	3.30E-04	—	—	1.21E+03
Mercury	1.55E-06	—	1.4E-04	1.21E+03
Selenium	3.73E-03	—	2.0E-02	7.18E+01
Thallium	9.07E-03	—	—	2.42E+01
Ag-108	1.78E-05	2.4E-12	—	1.07E+03
Cs-137	5.33E-58	3.6E-64	—	5.58E+03
Ra-226	2.22E-01	1.4E-06	---	2.42E+01

Overlying fine soil must be prevented from entering the coarser underlying media, to maintain the function of both the biobarrier and capillary barrier components. If fine soil fills the coarser media, it can serve as a conduit for both infiltrating water and for plant roots (Keck et al. 1992). Geotextile or a graded filter bed would be placed over the biobarrier to prevent fine soil intrusion.

This cover or barrier was designed to control surface exposures and inhibit biotic intrusion and infiltration for at least 500 years. However, without continual maintenance, the top fine-grained layer could erode because of wind and precipitation. Impacts to human health and the environment likely could be minimized to allowable levels through administrative and engineering controls. The cover has been constructed at pilot-scale and is, therefore, considered technically implementable. The relative cost of this cover is moderate.

9.5.3.2.2 SL-1 Type Cap—The SL-1 type barrier consists of layers of basalt cobbles underlain and overlain by gravel, with a rock armor surface. A conceptual drawing of the SL-1 type cap is given in Figure 9-3. The cap is designed to control surface exposures and inhibit biotic intrusion for approximately 400 years. However, this barrier does not reduce infiltration, does not promote runoff of rainfall and snowmelt, and does not promote lateral drainage of infiltration, which are typical functions of a closure cover. This barrier likely will increase infiltration rates relative to undisturbed soils because any rainfall or snowmelt on the barrier rapidly moves through the depth of the very porous rock armor and gravel-cobble layers, beyond the depth of evaporation. No transpiration would act to remove water because no vegetation would be present. This barrier, therefore, likely would increase risks associated with infiltration and leaching COCs to groundwater.

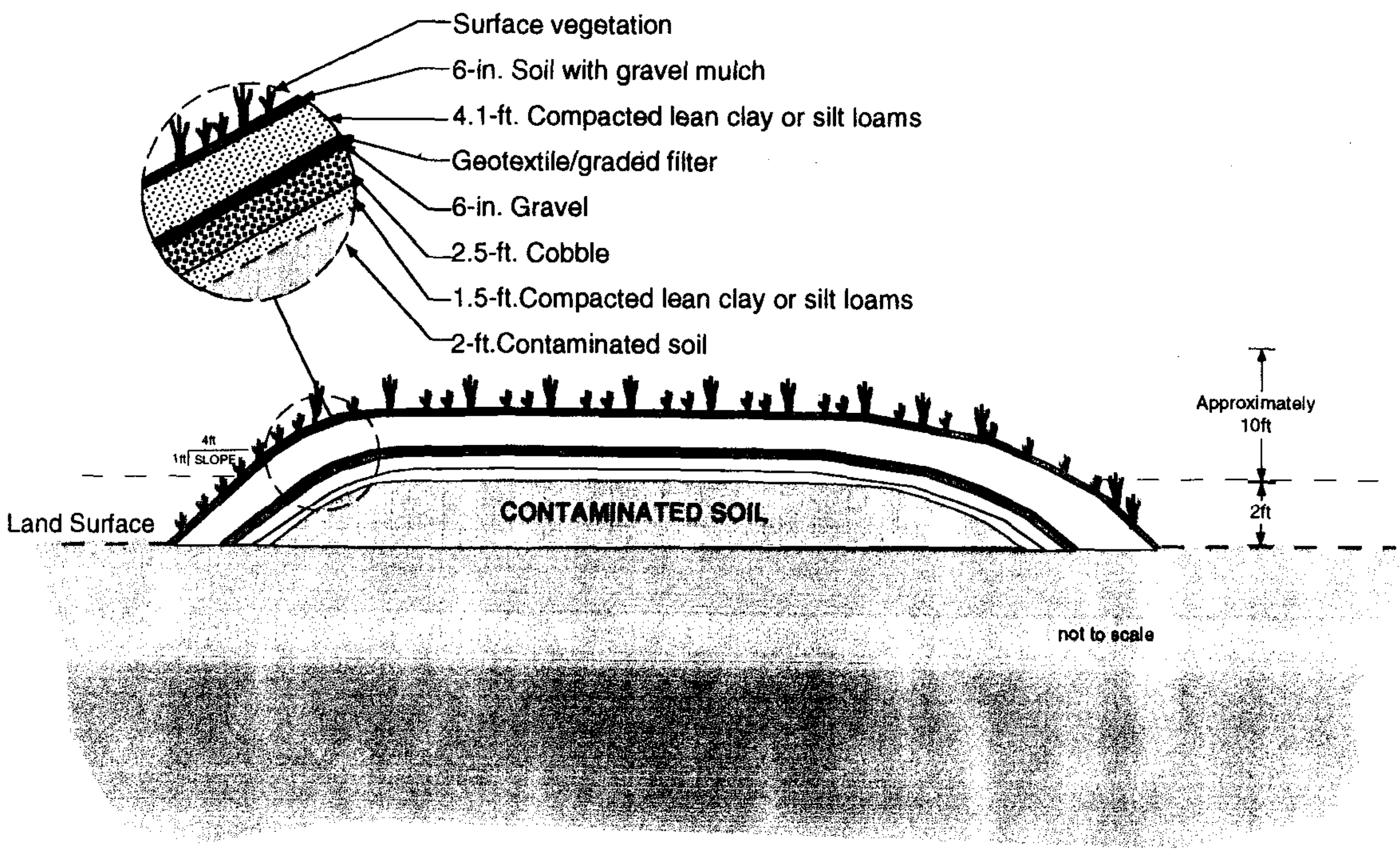


Figure 9-2. Conceptual drawing of a capillary barrier/biobarrier cover.

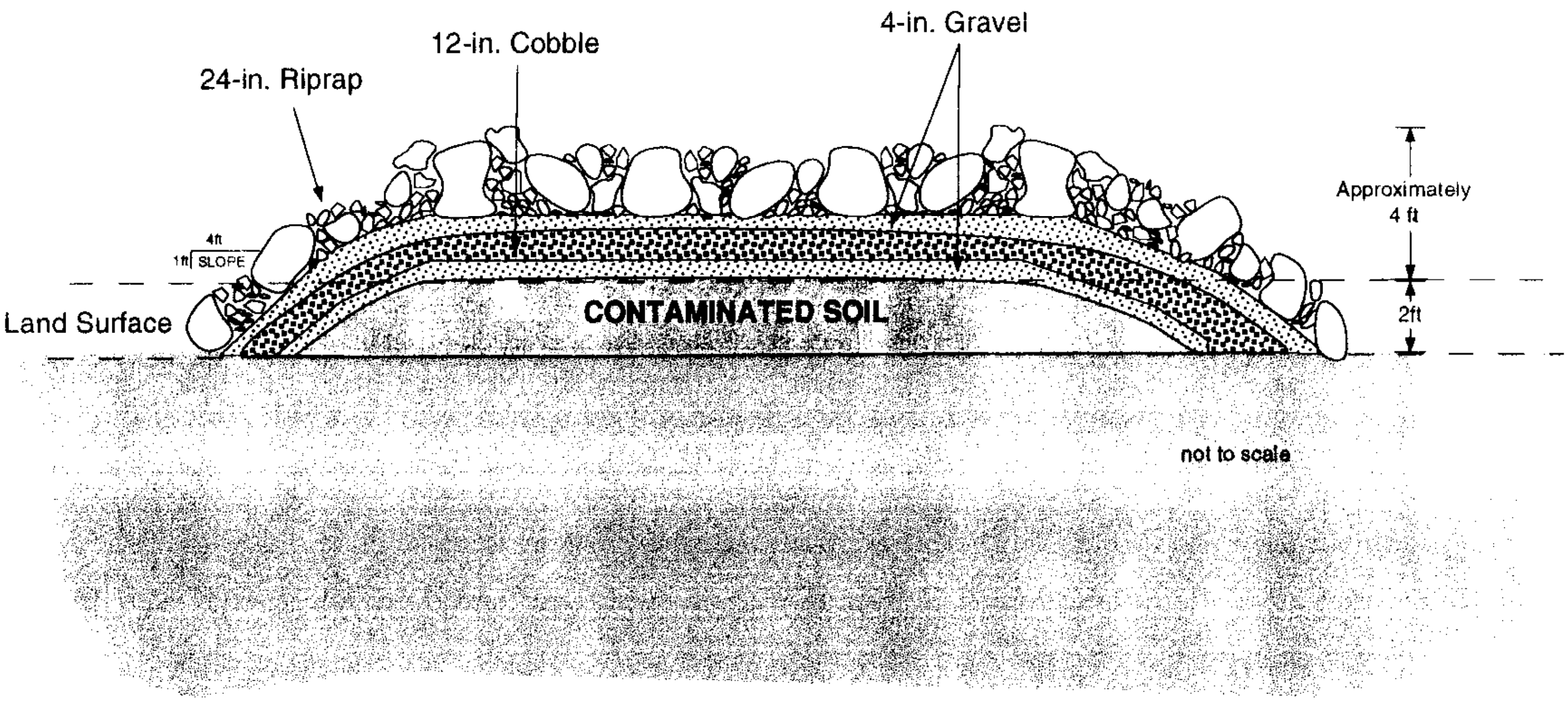


Figure 9-3. Conceptual drawing of an SL-1 type engineered barrier.

The SL-1 type cover is more appropriate than the capillary barrier/biobarrier-type barrier for WAG 5 soils because it is more effective in preventing biointrusion and less subject to erosion. Because the cost for constructing these engineered barriers is nearly equivalent (Burgess et al. 1998), the SL-1 type design was used as the representative engineered barrier in this FS.

9.5.3.3 Cap Integrity Monitoring and Maintenance. This option would apply to sites in which waste is left in place and contained under a Cap. Closure cover integrity monitoring and maintenance would be performed to assess the physical condition of the cap and to determine whether corrective actions are required for at least the 100-year period of institutional control. Monitoring would include visual inspections in combination with radiation surveys to determine whether animal burrows, erosion, or other processes had damaged the cap to a degree requiring maintenance. Maintenance would include filling burrows, repairing erosion damage and subsidence, and other activities identified as a result of monitoring.

Cap integrity monitoring and maintenance would be effective and implementable for the institutional control period. Estimated costs are moderate.

9.5.4 In Situ Treatment

In situ treatment options are implemented without significant excavation of contaminated media. Construction requirements may include drilling wells, digging trenches, constructing on-site process equipment, and other activities. In situ treatment options potentially applicable to WAG 5 include in situ vitrification, stabilization and solidification, soil flushing, phytoremediation, chemical leaching, and oxidation/reduction.

9.5.4.1 In Situ Vitrification. In situ vitrification (ISV) applies electric current to melt soil or other solid media at extremely high temperatures (1,600 to 2,000°C). Most radionuclides and heavy metals become immobilized within the vitrified mass, which is a chemically stable, leach-resistant material similar to obsidian. Volatile metals such as mercury and lead are captured in the off-gas system. Organic constituents are destroyed by pyrolysis or are volatilized and destroyed in the off-gas system. The ISV process reduces the overall waste volume, retards the mobility of heavy metals and radionuclides, and reduces the toxicity of organics. A new type of ISV, called planar ISV, is currently being tested and developed for use on Test Area North tanks, which have contents similar to those of the ARA-16 waste tank.

The effectiveness of this option in reducing risks to human health and the environment and in meeting RAOs is high for the ARA-16 tank waste and low for radioactively contaminated soils and the ARA-02 seepage pit sludge. The hazardous organic contaminants in the ARA-16 tank waste would be destroyed and the heavy metals immobilized, thereby reducing potential risks to human health and the environment. Because ISV would not destroy or reduce the toxicity of radionuclides in the radiologically contaminated soil or the ARA-02 seepage pit sludge, risk to human health from direct exposure would not be reduced. Implementability of ISV for the ARA-16 tank and ARA-02 seepage pit is considered moderate. Though ISV would reduce or eliminate the ecological risk from the chemically contaminated soils by eliminating the exposure pathway, the technical implementability is low because of the shallow depth of contamination. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. Costs are high relative to other in situ treatment technologies. This option is retained as a process option for the ARA-16 tank waste, but is eliminated from further consideration for radioactively and chemically contaminated soils and seepage pit sludge because of its minimal benefits in reducing human health risk, low implementability at the ecological risk sites, and high cost.

9.5.4.2 *In Situ Stabilization and Solidification.* In situ stabilization and solidification is a physical-chemical remedial technology. Stabilization refers to technologies that reduce the hazard potential of a waste by converting the contaminants into less soluble or toxic forms. Solidification refers to technologies that encapsulate the waste in a monolithic solid of high structural integrity. Solidification does not necessarily involve a chemical interaction between the waste and the solidifying reagents, but may mechanically bind the waste into a monolith. When solidified, contaminant transport is restricted by reducing the surface area exposed to leaching or by isolating the waste within an impervious matrix.

Most solidification and stabilization technologies are relatively simple to implement with mechanical equipment and standard stabilizing or solidifying agents. Stabilizing or solidifying agents may include lime or fly ash pozzuolans, Portland cement, silicate, apatite, thermoplastics, or derivatives of these and other reagents. A treatability study to determine appropriate solidification and stabilization reagents for contaminants associated with the WAG 5 soils, tank waste, and seepage pit sludge would be required. Several reagents would be evaluated primarily on the basis of mixability, strength, and leaching of radionuclides and chemical COCs from stabilized or solidified mixtures.

The effectiveness of this option in reducing risks to human health and the environment and in meeting RAOs is low for contaminated soil and the ARA-16 tank waste and moderate for the ARA-02 seepage pit sludge. Exposure to direct radiation and toxicity of the stabilized soil and ARA-16 tank waste would not be significantly reduced, though the contaminants would be less mobile. An in situ process that would stabilize the seepage pit sludge and encapsulate the entire seepage pit in a grout type monolith would reduce exposure to direct radiation and contaminant mobility. Environmental risks would be reduced or eliminated by interrupting the exposure pathways. Toxicity of the COCs would not be reduced. Volume of contaminated media would increase by 30 to 50% because of the addition of stabilization agents, which would raise the surface grade of the stabilized area several feet. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls.

Implementability is low for the ARA-16 tank waste. Many compounds in the ARA-16 tank waste are incompatible with stabilizing agents. The ARA-16 tank waste has high concentrations of organics, which are known to interfere with the stabilization process. Thus, pretreatment of the ARA-16 tank waste to destroy organics would be required before stabilization. Chemical agents that destroy organics, such as potassium permanganate, also have been shown to significantly reduce the strength and durability of the final stabilized waste form (Richardson et al. 1998). An in situ thermal treatment technology has not been developed that would be applicable for the small waste volume and small tank volume associated with ARA-16. The technology could be applied to the ARA-02 seepage pit sludge because the organic concentrations are much lower than in the ARA-16 tank waste; hence implementability for the ARA-02 seepage pit and associated septic system is moderate. Because the sludge is dry and compacted, it will be difficult to effectively mix the sludge with a stabilizing agent. The technology is not technically implementable for surface soil contamination because the depth of contamination in most areas is less than 1 ft. The cost of in situ stabilization and solidification is relatively high. This option is eliminated from further consideration for ARA-16 tank waste and all soil sites because of its low effectiveness in reducing human health risk, uncertainties for implementation, and high cost, but is retained for ARA-02 seepage pit sludge.

9.5.4.3 *In Situ Soil Flushing.* In situ soil flushing, considered for ARA-02, ARA-12, ARA-23, and PBF-16 involves the injection of water and other reagents into contaminated soils to solubilize COCs. The resultant solution migrates to the water table where downgradient wells recover the fluids for separation of contaminants and reuse of the reagents in the process of soil flushing. The effectiveness of this option is low. Soil flushing, in combination with physical separation, was previously tested at bench-scale on Test Reactor Area (TRA) Warm Waste Pond (WWP) sediments with poor results (EG&G 1991).

No soil washing treatability studies have been performed to date on INEEL soil contaminated with toxic metals.

In situ soil flushing is complex because of the requirement for hydraulic control over the extractant fluid and difficulties in uniformly contacting the extractant fluid with contaminated media. Therefore, implementability is classified as low. Costs are high relative to other in situ treatment technologies. Impacts to human health and the environment would be minimal.

This option is eliminated from further consideration because of its low effectiveness, technical implementability, and high cost.

9.5.4.4 Phytoremediation. Phytoremediation, considered for contaminated soils at ARA-01, ARA-12, ARA-16, ARA-23, ARA-25, and PBF-16, is an emerging innovative technology that uses surface vegetation to uptake toxic metals and radionuclides through roots. Vegetation types may include grasses, shrubs, and trees. Arthur (1982) observed radionuclide uptake in INEEL vegetation such as the Russian thistle, crested wheatgrass, and gray rabbitbrush growing on waste disposal sites. The metals and the radionuclides incorporated in biomass may be recovered by harvesting and incinerating the vegetation. Incinerator residuals would require disposal in a low-level radioactive waste, RCRA, or mixed-waste landfill.

Phytoremediation is most applicable for contaminants distributed within the rooting zone, typically a maximum depth of 1 m (EPA 1997). Parameters affecting application of this process include soil type and characteristics, contaminant type, chemical species, and climate. Immobile precipitated contaminant species are not typically treatable by this method without soil amendments. For example, ethylenediaminetetraacetic acid (EDTA) can be used as a soil amendment (Chaney et al. 1997) to mobilize lead and ammonium nitrate (DOE 1997) to displace exchangeable cations like Cs-137. Treatability studies are typically required to implement this technology successfully (EPA 1997).

A number of plant species were evaluated for remediating low levels of Cs-137 and Sr-90 in soil at the Brookhaven National Laboratory (DOE 1997). Hydroponic screening studies identified Reed canary grass (*Phalaris arundinacea*), Indian mustard (*Brassica juncea*), tepary bean (*Phaseolus acutifolius*), and cabbage (*Brassica oleracea*) as potential hyperaccumulators of Cs-137. Subsequent studies in pots evaluated Cs-137 uptake from soil by these species. Soil amendments for releasing cesium sorbed to clay minerals, identified as a major impediment to phytoremediation of cesium, also were evaluated. The most successful treatment consisted of amending soil with ammonium nitrate to promote release of cesium, allowing for subsequent uptake by cabbage. However, the longer cesium resides in the soil before phytoremediation, the more strongly it adsorbs to the soil, making soil amendments less effective in making the cesium available for plant uptake[b]. Cabbage grown in Cs-137-contaminated soils amended with 80-mole ammonium nitrate per kilogram of soil showed bioaccumulation factors of approximately 3, measured as the activity of Cs-137 in dry shoot mass divided by the activity of Cs-137 in dry soil mass. This study indicated that reduction of initial Cs-137 soil activities of approximately 400 pCi/g to less than 100 pCi/g (75% activity reduction) using cabbage would take at least 15 years. The study also concluded that bioaccumulation ratios would decrease as activities decreased, making removal to lower activities unlikely in a reasonable time period.

Effectiveness of this technology for WAG 5 soil sites is uncertain because no treatability studies have been performed for Cs-137 or Ag-108m in WAG 5 soils. The soils at WAG 5 contain about 30%

b. Broomfield, B. J., Lockheed Martin Idaho Technologies Company, December 1998, Personal communication with Dr. Stephen Ebbs of Cornell University, Ithaca, New York.

clays (Bartholomay, Knobel, and Davis 1989) and the radionuclide contamination has been in the soil for more than 30 years, a combination that will make phytoremediation difficult to implement. Furthermore, contamination at WAG 5 sites includes discrete immobile particles, which are not readily recoverable by phytoremediation.

The technical implementability of this technology at the WAG 5 soil sites also is uncertain. The relatively short growing season of the INEEL sagebrush steppe environment constrains both species selection and biomass production. If nonarid climate vegetation species were used, which would be required to maximize biomass production, supplemental irrigation probably would be required, which would be very difficult to implement at WAG 5 and also could flush mobile contaminants to greater depths at which recovery may not be possible. The maximum detected Ag-108m concentration is 67.2 pCi/g at ARA-12, and the maximum detected Cs-137 concentration is 2,140 pCi/g at ARA-23. Reduction to the human health risk PRG of 1.2 pCi/g for Ag-108m and 23 pCi/g for Cs-137 would require a 98 to 99% reduction in concentrations, which is likely unattainable. Costs of this technology are low relative to containment and other in situ treatment technologies. Impacts to human health and the environment would be minimal because the plants would be harvested before setting seed.

Phytoremediation is excluded from further consideration because of its restricted applicability, uncertain effectiveness, and uncertain technical implementability.

9.5.4.5 Chemical Leaching. In situ chemical leaching can be effective in removing specific COCs from waste. This technology was considered only for the ARA-16 tank waste because its application requires confinement of the waste for process control and complete isolation from the environment to prevent release of contaminants. Chemical leaching is accomplished by the introduction of solvents or chelating agents to selectively dissolve contaminants in the waste. Chemicals typically used include nitric acid, oxalic acid, or EDTA. The solution would then be pumped from the tank, treated, and disposed of. Creation of a secondary waste stream adds to the complexity of the treatment, particularly because the chemicals used may not be typical of those used elsewhere on INEEL, and, therefore, could require a separate treatment system.

The increased complexity in addition to the small quantity of tank waste would make the cost of chemical leaching high and the implementability difficult. The effectiveness of this option in reducing risks to human health and the environment is estimated as low because of the uncertainty in the ability to completely remove all the COCs from the ARA-16 tank waste. Impacts to human health and the environment would be minimal. Estimated costs are moderate. Because of its low effectiveness and technical implementability, chemical leaching was eliminated from further consideration.

9.5.4.6 Oxidation/Reduction. Oxidation/reduction processes were considered for in situ treatment for the ARA-16 tank contents only because of the need for confinement and isolation from the environment. Oxidizing and reducing reagents are mixed with the waste to destroy toxic organics or to change the oxidation states of heavy metals. However, its efficiency relies on thorough mixing of the chemicals with the waste. Thorough mixing may be difficult to achieve because the tank is small and not equipped with mixers. The small quantity of tank waste would make the cost of oxidation/reduction high and the implementability difficult.

The effectiveness of this option in reducing risks to human health and the environment is estimated as low because of the uncertainty in the ability to completely treat all the COCs in the ARA-16 tank waste. Impacts to human health and the environment would be minimal. Because of its low effectiveness, low technical implementability, and high cost, in situ oxidation/reduction was eliminated from further consideration.

9.5.5 Removal

This general response action includes process options for excavating and removing contaminated media. Once removed, materials would be treated ex situ and packaged for disposal, or disposed of without treatment. An engineered facility located either on- or off-Site would be used for disposal. Removal options evaluated for WAG 5 include excavation with conventional earth-moving equipment, truck-mounted vacuum systems, and excavation using robotics.

9.5.5.1 Conventional Excavation. Excavation with backhoes, scrapers, loaders, bulldozers, and trucks represents standard excavation techniques using conventional equipment. Conventional earth-moving equipment has been demonstrated to be completely effective for removing contaminated soil to depths of up to 6.1 m (20 ft) at the INEEL. Equipment operators can be shielded in positive-pressure cabs as needed to reduce exposures during excavation. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. Costs are low and conventional excavation is technically and administratively feasible. Therefore, conventional excavation is retained for further consideration.

9.5.5.2 Vacuum Extraction. Vacuum extraction uses the kinetic energy of a high-velocity air stream to penetrate, expand, and break up soil. Loosened soil and rocks are captured by a vacuum air stream and stored in a holding tank. The combination of a high-output compressor, efficient nozzle design, and strong vacuum make digging easier and faster in all soil conditions. The excavation head can remove 2 to 5 in. of soil in a single pass, pick up and pass rocks as large as 7 in. in diameter, and trench as deeply as 20 ft.

Wet or dry vacuum capability is used for difficult conditions in which a high-pressure water stream is needed to break up the soil. Addition of a heat source to the vacuum hopper allows separation of some contaminants from the soil. Commercial vacuum excavation units can be fitted with high-efficiency particulate air (HEPA) filtration for hazardous and radioactive applications.

Compared to standard excavation methods, use of soil vacuuming could greatly reduce the volume of soil excavated. It also would facilitate surface soil removal around facilities to which access is limited. Impacts to human health and the environment during removal activities likely could be minimized to allowable levels through administrative and engineering controls. This process option is technically and administratively feasible and costs are relatively low. This process option is retained for further consideration.

9.5.5.3 Excavation with Robotics. Excavation using robotics represents nonstandard excavation techniques using remotely operated equipment. While these technologies have been demonstrated at the INEEL, robotic excavation has not been globally demonstrated to be effective and implementable. Therefore, site-specific evaluation is required. Previous INEEL experience with contaminated site excavation demonstrates that this technology would reduce worker exposures; however, costs are relatively high. Furthermore, with the exception of ARA-16 tank waste, this technology is not required for the occupational exposures associated with WAG 5. This technology is, therefore, eliminated from further consideration.

9.5.6 Ex Situ Treatment

Ex situ treatment is applicable to excavated contaminated media. The treated materials are either disposed of on- or off-Site. Relative to comparable in situ treatment technologies, ex situ treatment ensures that the effectiveness of the treatment process can be verified and that the contaminated media are treated to designated criteria. Ex situ treatment options potentially applicable to WAG 5 include physical separation using screening, flotation, attrition scrubbing, or a gamma monitor/conveyer/gate system; thermal treatment, chemical fixation and stabilization, and soil washing. Each of these is described in the following subsections.

9.5.6.1 Physical Separation Using Screening. This technology takes advantage of the typical tendency of radionuclides and heavy metals to be distributed more into soil fines (silts and clays) than into coarse components (coarse sands, gravel, and cobbles). This is often the most effective separation step in a soil-washing process. Excavated contaminated soils can be passed through progressively finer screen sizes, using grizzly shakers or other standard process equipment, to separate fine-grained from coarse-grained fractions. This technology may be used alone or in combination with other treatment technologies to reduce the volume of contaminated soils for disposal.

The physical separation technology was tested in treatability studies using Cs-137-contaminated TRA WWP sediments and soils (EG&G 1991) and was judged effective at separating fine-grained from coarse-grained fractions. However, the effectiveness of screening in reducing the volume of contaminated soils is likely limited. Cesium-137 in the WWP sediments and soils was not sufficiently concentrated in the fine-grained fraction to result in separation of a soil fraction that could be returned to the site. Results indicated approximately 30% of the total cesium present was in +8 mesh material (gravel and cobbles), which represented at least 60% by weight of the WWP sample sediments. At WAG 5 sites, 68 to 90% of soils can pass through a 150-mesh screen; hence, physical separation is not likely to result in a reduced volume of soil.

This technology has not been tested for separating WAG 5 toxic metal COCs from INEEL soils. Effectiveness could be determined only through treatability studies.

This option is technically implementable using standard process equipment. Costs are relatively low. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. This technology is screened from further consideration on the basis of low effectiveness for WAG 5 soils.

9.5.6.2 Physical Separation Using Flotation. Flotation separates fine-grained from coarse-grained soils by increasing their differences in settling velocities in a water clarifier and is applicable only for contaminants that are preferentially partitioned on the fine-particle fraction of the soil. Soils are added to a conical tank filled with water, and air is introduced through diffusers or impellers. The air bubbles attach to the particulate and the buoyant forces on the combined particle and air bubbles are sufficient to cause fine-grained particles to rise to the surface at which they can be recovered by skimmers. Coarse-grained material settles to the bottom and is removed.

This technology was tested in treatability studies using TRA WWP sediments and soils (EG&G 1991). The tests demonstrated that this process is effective at separating fine-grained from coarse-grained fractions. However, because Cs-137 in WWP sediments and soils was not sufficiently concentrated in the fine-grained fraction to result in a separate soil fraction that could be returned to the site, the effectiveness of flotation in reducing the volume of contaminated soils is likely to be limited. This technology also may produce a secondary liquid waste stream.

This option is technically implementable using standard process equipment. Costs are relatively low. Impacts to human health and the environment during operations could be minimized to allowable levels through administrative and engineering controls. However, this technology is eliminated from further consideration on the basis of low effectiveness.

9.5.6.3 Physical Separation Using Attrition Scrubbing. Attrition scrubbing consists of mechanical agitation of soil and water mixtures in a tank to remove contaminants bound to the external surfaces of particles. This technology was determined ineffective for Cs-137 removal from WWP sediments and soils (EG&G 1991) because only 18% of the Cs-137 was associated with phases in and on the sediment particle coatings. The remaining 82% of the Cs-137 was associated with the internal mineral lattice structure of the particles and could be removed only by dissolution of the particle. However, it was concluded that this technology, combined with screening, could potentially be effective for soils with initial activities within 10 times the PRG for Cs-137 (i.e., 233 pCi/g). Treatability studies of representative samples from WAG 5 radionuclide-contaminated soil would be required to determine the effectiveness of this technology, alone or in combination with other technologies, to reduce the volume of contaminated soils.

This technology has not been tested for separating WAG 5 toxic metal COCs from INEEL soil. Effectiveness could be determined only through treatability studies. However, it is anticipated that the removal efficiency for the toxic metals at the sites with ecological risk would be very low because the initial contamination levels are low.

Impacts to human health and the environment during operations could be reduced to acceptable levels through administrative and engineering controls. Costs are estimated as moderate. Because a secondary waste liquid waste stream would be produced and the effectiveness for reducing the volume of contaminated materials at WAG 5 sites is uncertain, this technology is screened from further consideration.

9.5.6.4 Physical Separation Using Gamma Monitor/Conveyer/Gate System. This technology would be used only on soils with radiological contamination exceeding PRG levels. The technology combines a feed hopper, a conveyer belt, gamma spectroscopy, and a gate to separate soils into two categories based on gamma activity. Materials with radiological contamination at levels greater and less than PRGs are diverted to different outlets. Soils with contaminant concentrations less than PRGs could be returned to the excavation, while soils with contaminant concentrations exceeding PRGs could be treated further or directly disposed of at an appropriate facility.

Either germanium or sodium iodide gamma radiation detectors could be used. The gamma monitoring/conveyer/gate system is most effective when combined with other technologies in a treatment train. For example, vitrification can be applied following soil segregation to stabilize the soils containing the highest activities. This option is most applicable to sites with undisturbed soils after contamination (i.e., the soils are not homogenized relative to contamination). These types of sites may include those with wind- and water-deposited contamination. This technology is likely to be less effective for sites at which contaminated soils have been previously consolidated, such as those consolidated in the WWP 1952 and 1957 cells (EG&G 1991). Previous applications at other sites (Thermo NUtech 1997, 1996, 1995) claimed high volume reductions. However, effectiveness is dependent on the soil type and homogenity of the soils.

Impacts to human health and the environment during operations could be reduced to acceptable levels through administrative and engineering controls. The effectiveness of this technology for WAG 5 soils and sediments is uncertain because it has not been tested at the INEEL for separation based on the Cs-137 PRG of 23.3 pCi/g. However, the technology has been successfully demonstrated to reduce volumes of radiologically contaminated soils at several other locations. Physical separation is moderately implementable for WAG 5 soils because much of the radiological contamination is wind- or water-deposited. Costs are estimated as moderate. The physical separation technology has been retained for further evaluation for ARA-12, ARA-16, and ARA-23 radiologically contaminated soils.

9.5.6.5 *Thermal Treatment.* This option would consist of incinerating excavated radiologically and chemically contaminated soil or tank waste at high temperatures to produce a stable inert waste form. No reduction in radioactivity would occur; therefore, proper disposal after treatment would be required. In addition, this option alone would not reduce risks associated with direct radiation exposure if treated materials remained on site. Organic COCs would be destroyed, but the toxicity of radionuclides and heavy metals would not be reduced. The mobility of the radionuclides and heavy metals via leaching and infiltration to groundwater could be reduced if a leach-resistant waste form were produced. This technology may potentially improve the effectiveness of separation technologies by providing a stable waste form for disposal of relatively high-concentration solids. However, it is unlikely that any WAG 5 soil fractions from separation processes would be of high enough activity to require stabilization before disposal. This technology, therefore, offers little improvement in effectiveness for soils over excavation and disposal alone.

The WERF incinerator at the INEEL is a low-level mixed waste thermal treatment system and will be operational through 2003. Incineration detoxifies organics and can achieve a waste volume reduction of 200:1. Review of the waste acceptance criteria for WERF (DOE-ID 1998) indicated that the ARA-02 seepage pit sludge, which has low concentrations of PCBs and is not TSCA-regulated, can be accepted for treatment in the WERF incinerator when blended with other waste to reduce the PCB concentrations. However, the ARA-16 tank waste, which is TSCA-regulated for high PCB concentrations, cannot be treated at WERF because of its high concentrations of PCBs and alpha-emitting radionuclides. Costs are estimated as low, and implementability is high. Therefore, this option is retained for the ARA-02 seepage pit sludge, but not for the ARA-16 tank waste.

However, the Advanced Mixed Waste Treatment Facility (AMWTF), presently in the design phase, will be located at RWMC and is expected to become operational in 2003. The AMWTF will provide storage and treatment of TRU and low-level mixed waste. The ARA-16 tank waste could be treated at the AMWTF, which will consist of the following units:

- Miscellaneous process units for waste pretreatment and sorting, supercompaction, macroencapsulation, and evaporation of scrubber blowdown and decontamination wastewaters

- An incinerator equipped with an air pollution control system.

Implementability of this option is moderate. Costs would be moderate to high, depending on whether WAG 5 bears a portion of the capital construction costs of the treatment facility. This option is retained for further consideration only for the ARA-16 tank contents because effectiveness in treating the organic contaminants in the tank waste is high.

9.5.6.6 *Chemical Fixation and Stabilization.* Chemical fixation and stabilization technologies immobilize radioactive and hazardous constituents in waste by using additives that bind them into a solid waste form. Solidification and stabilization processes commonly are used to treat materials similar to the ARA-16 tank waste and ARA-02 seepage pit sludge, and soils that fail toxicity characterization leaching procedure (TCLP) analysis because the mobility of the contaminants is reduced. It would not reduce risks associated with direct radiation exposure. Toxicity of the radionuclides and toxic metals would not be reduced; however availability of COCs and exposure risks via soil ingestion and plant uptake would be reduced. Disposal of the treated waste in a low-level radioactive landfill would be required for the radiologically contaminated soils from ARA-02, ARA-12, ARA-16, ARA-23, and ARA-25. Soil at PBF-16 is not radiologically contaminated, therefore it could be disposed of at the CFA Landfill or other suitable location. Disposal in a mixed waste landfill would be required for the waste in the ARA-02 seepage pit and the ARA-16 waste tank. Mobility via leaching and infiltration to groundwater would be reduced. Volumes of contaminated media would increase by 30 to 50%.

Though this technology is used to treat PCB-contaminated waste, it will be difficult to locate a mixed waste disposal facility that can accept the ARA-16 tank waste without first reducing the PCB concentration to below 50 ppm before solidification and stabilization treatment.

Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls. The implementability of this option is moderate. Extensive handling and mixing of the soils would be required to produce a homogeneous waste form. However, standard construction and soil handling equipment could be used. Treatability studies would be required to define the amendments, concentrations, mixing times, and other process variables. Costs would be low to moderate relative to other ex situ treatment options. This option is retained as a possible treatment process for the ARA-02 seepage pit sludge and the ARA-16 tank waste only. The option is eliminated from further consideration for the soil sites because the radiation exposure risk to human health would not be reduced at contaminated soil sites. Furthermore, the costs of stabilization are not justified for ARA-01 and PBF-16 because the contamination is below the TCLP limits.

9.5.6.7 Soil Washing. The soil washing option would consist of chemically extracting contaminants from excavated soils and debris to produce clean soils and concentrated residual waste. Clean soils would likely be returned to the excavation site, and concentrated residual waste would be properly disposed of either at an on-Site or off-Site landfill. Concentrated acids, water, surfactants, brines, and carbonates are the most likely extractants.

Soil washing using water and concentrated nitric acid, in combination with physical separation, has previously been tested at bench-scale on TRA WWP sediments with poor results. Though the removal efficiency of Cs-137 for WWP sediments for the greater than +8 mesh fraction (gravels and cobbles) exceeded 90%, Cs-137 activity in the treated solids still exceeded the 690-pCi/g WWP treatment goal (EG&G 1991; WINCO 1994; DOE-ID 1995). Because of the large percentage (68 to 90%) of fines (150 mesh) in the soils at WAG 5 sites, little or no volume reduction of Cs-137-contaminated soil would be achieved using this method.

No soil washing treatability studies have been performed to date using INEEL soils contaminated with toxic metals. Copper and mercury, as well as radionuclides including U-235 and U-238, have been removed from soils at other locations using a combination of screening, flotation, and extraction with much of the volume reduction occurred at the screening step (EPA 1995). Treatability studies would be required to determine the effectiveness of soil washing for removing copper, mercury, selenium, and thallium from WAG 5 soils.

Toxicity of the radionuclides and toxic metals would not be reduced. This technology would produce large quantities of secondary waste requiring treatment. This process option is estimated to have low to moderate effectiveness for reducing risks to human health and the environment and meeting RAOs at WAG 5. This option would not significantly improve protection of human health and the environment at WAG 5 sites. Impacts to human health and the environment could be minimized to allowable levels through administrative and engineering controls.

The implementability of this option is low, and costs are moderate relative to other ex situ treatment technologies. This option is eliminated from further consideration because of its low effectiveness for soils with high percentages of fines common to WAG 5 sites.

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9.5.7 Disposal

The suitability of disposal facilities located on and off the INEEL is evaluated below for WAG 5 contaminated soils and waste.

9.5.7.1 On-Site Disposal at the INEEL. Three on-Site locations outside of WAG 5 could potentially be used for disposal of the radiologically contaminated soils from the WAG 5: the RWMC, the WWP 1957 cell at TRA, and the proposed INEEL CERCLA Disposal Facility (ICDF) (see Section 9.5.7.1.3 below). In addition, a location for permanent disposal of contaminated soils could be selected within WAG 5. The CFA landfill could be used for nonradioactive soils contaminated with toxic organics and metals at levels that exceed ecological PRGs but pass the TCLP. These five potential disposal locations are discussed below.

9.5.7.1.1 Disposal at RWMC—Disposal of radiologically contaminated soil at the RWMC is effective in protecting human health and the environment and in meeting RAOs for WAG 5. The RCRA-regulated hazardous materials cannot be disposed of permanently at the RWMC but can be stored for future treatment. Disposal requirements for contact-handled LLW are stated in the INEEL waste acceptance criteria (DOE-ID 1998). Characterization requirements include quantification of specific radionuclides. Soils may be added to fill voids in waste containers if a plan for this type of disposal is submitted and approved. Bulk disposal of soil is not currently allowed.

This option has been used for prior INEEL actions conducted under CERCLA and is both technically and administratively implementable. Costs would be relatively high. Impacts to human health and the environment could be minimized through administrative and engineering controls. Currently, disposal of low-level radiologically contaminated soils at the RWMC is discouraged. However, INEEL policy does not prohibit the practice. An estimated 55,813 m^3 (73,000 yd^3) of disposal capacity remain at the RWMC.

This disposal option is retained for further consideration for WAG 5 radiologically and chemically contaminated soils because no soils are expected to be designated as hazardous waste under RCRA regulation. The RWMC will be considered for temporary storage of the ARA-02 seepage pit sludge and ARA-16 tank waste.

9.5.7.1.2 Disposal at the Warm Waste Pond—Disposal of WAG 5 radiologically contaminated soils at the WWP 1957 cell would provide protection of human health and the environment and meet RAOs. This option has been used for previous INEEL actions implemented under CERCLA and is, therefore, technically and administratively feasible for disposal of relatively small volumes of low-level radiologically contaminated soil. However, the available disposal capacity remaining at the WWP, approximately 7,600 m^3 (10,000 yd^3), would likely not be sufficient to contain WAG 5 contaminated soil volumes. Estimated costs are relatively low. Based on the limited disposal capacity remaining, this disposal option is not retained for further consideration.

9.5.7.1.3 Disposal at the Proposed INEEL CERCLA Disposal Facility—Currently, a repository for low-level radiologically contaminated soil is being considered to consolidate INEEL contaminated soil. If implemented, the ICDF will probably be located at the Idaho Nuclear Technology and Engineering Center (INTEC), and is projected to become operational by the end of the year 2001. The ICDF would accept INEEL CERCLA and Environmental Restoration Program soil and debris costs are expected to be much lower than those for the RWMC or private low-level radioactive waste landfills. This option is retained for further consideration pending a final decision.

9.5.7.1.4 Soil Consolidation within WAG 5—Consolidating soils at WAG is effective in protecting human health and the environment and in meeting RAOs for WAG 5. This option has been used for previous INEEL actions and is technically feasible for disposal of the radiologically contaminated and nonradioactive soils contaminated with metals. However, administrative implementability issues addressing public acceptance cannot be determined until review comments are received on the WAG 5 proposed plan. Costs would be relatively low. Impacts to human health and the environment could be minimized through administrative and engineering controls.

This disposal option is implementable for the WAG 5 radiologically and chemically contaminated soils and retained for further evaluation.

9.5.7.1.5 Disposal at the CFA Landfill—The CFA landfill is projected to continue to operate at least 10 to 15 years in the future. Soils disposed of at the CFA landfill must meet facility acceptance criteria (DOE-ID 1998) as well as state and federal regulations. This option is considered only for nonradioactive soils from the ecological risk sites ARA-01, and PBF-16.

Characterization requirements would be minimal and could be met by collecting and analyzing samples during excavation. The CFA landfill accepts bulk shipments of industrial waste; therefore, no containerization would be required.

The effectiveness of this option at WAG 5 is high because the contaminated media are removed from the area. This option is technically and administratively implementable. Costs are estimated as low. This option is retained for further evaluation.

9.5.7.2 Off-INEEL Disposal. Three disposal facilities located outside of the INEEL are potentially suitable for disposal of contaminated soil from WAG 5. The Nevada Test Site (NTS) near Mercury, Nevada, is a permanent radioactive waste disposal facility owned and operated by DOE. The Envirocare facility, located near Clive, Utah, is a privately owned and operated disposal facility for low-level and mixed waste. Waste Control Specialists operates a broad-based low-level and mixed waste treatment, storage and disposal site in Andrews County, Texas.

9.5.7.2.1 Nevada Test Site—Two locations within the NTS are approved by DOE for disposal of defense-related low-level and mixed waste (DOE-Nevada 1996). Present legal challenges prevent the disposal of INEEL soils at NTS because the INEEL is not yet an approved waste generator. It is assumed that these legal issues will be resolved by the time waste generated from remediation of WAG 5 sites requires disposal. The NTS is located approximately 970 km (600 mi) southwest of the INEEL. The NTS is not serviced directly by rail spur; therefore, waste transport to the NTS from the INEEL would be either directly by truck or by both rail and truck.

This option is effective at protecting human health and the environment and meeting RAOs. Impacts to human health and the environment could be minimized to acceptable levels through administrative and engineering controls. While costs have not yet been determined, they will likely be high. Though implementability is uncertain, the INEEL is making an effort to become an approved waste generator. Therefore this option was retained for further consideration.

9.5.7.2.2 Envirocare—The Envirocare facility, located approximately 480 km (300 mi) from the INEEL in Clive, Utah, is permitted to accept specific types of low-level radioactive and mixed waste. The facility's disposal cells have three synthetic liners with a leachate collection system for each liner. In addition, the cells are enclosed in a natural clay barrier to further ensure long-term protection of the environment. The use of the Envirocare disposal facility by WAG 5 will depend on available disposal capacity, the ability of WAG 5 waste to meet waste acceptance criteria, and the continued operation of the site under permit and license from the State of Utah. Envirocare is accessible by rail from the INEEL, obviating intermodal transport.

Impacts to human health and the environment likely could be minimized to allowable levels through administrative and engineering controls during transportation from INEEL to the facility. This process option is, therefore, technically and administratively implementable. Relative costs for this option are moderate. The Envirocare facility is, therefore, retained for further consideration.

9.5.7.2.3 Waste Control Specialists LLC—The WCS facility, located in Andrews County, Texas, is a permitted treatment, storage, and disposal facility for low-level radioactive, RCRA, and TSCA mixed waste. Radioactive concentrations in excess of Class C and TRU limits can be accepted for treatment, and TSCA and RCRA waste can be accepted for treatment and disposal. At this time, all permits have been obtained with the exception of the low-level waste disposal license, which is pending. It is assumed that WCS will obtain permits to accept low-level and low-level mixed waste for disposal in time to satisfy WAG 5 requirements.

The disposal units are RCRA-compliant with independent liner and leachate collection systems. In addition, the cells are enclosed in a natural clay barrier to further ensure long-term protection of the environment. Use of the WCS disposal facility will depend on final approval for disposal of LLW, available disposal capacity, the ability of WAG 5 waste to meet the waste acceptance criteria, and the continued operation of the site under permit and license from the State of Texas. The WCS facility is accessible by rail from the INEEL, obviating intermodal transport.

Impacts to human health and the environment likely could be minimized to allowable levels through administrative and engineering controls during transportation from INEEL to the facility. Because the low-level waste disposal permit is still pending, implementability is uncertain. Relative costs for this option are moderate. The facility is retained for further consideration.

9.5.8 Summary

The environmental monitoring process options that were retained include air, soil, and groundwater monitoring. Institutional control actions include fences, cap integrity monitoring and maintenance, legal restrictions (e.g., deed restrictions), and surface water diversion.

Containment options retained include the native soil cover and the SL-1 type engineered barrier.

The representative removal technologies considered include standard construction equipment such as backhoes and bulldozers as well as vacuum extraction.

The only in situ treatment technology retained for the ARA-16 tank waste is ISV. In situ vitrification is retained because it is the only in situ technology that can effectively immobilize radionuclides and other inorganic contaminants and destroy the organic contaminants including PCBs. For ARA-02 seepage pit sludge, in situ stabilization was retained.

Because radioactivity cannot be destroyed, ex situ treatment options for soils contaminated with Cs-137 were evaluated based on their ability to reduce the overall volume of contaminated soils. The physical separation using the gamma monitor, conveyer, gate system is the only feasible method that meets this criterion. Ex situ thermal treatment and stabilization were retained for further consideration in treatment of the ARA-02 seepage pit sludge and the ARA-16 tank waste.

The on-Site disposal locations that were retained for further evaluation include the RWMC, the proposed ICDF, a soil consolidation site within WAG 5, and the CFA Landfill. Off-Site treatment and disposal facilities retained for further analysis include the Nevada Test Site, Envirocare, and Waste Control Specialists.

9.6 References

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42 USC § 9601 et seq., *United States Code*, October 21, 1976, "Resource Conservation and Recovery Act."

40 CFR 300, *Code of Federal Regulations*, Title 40, "Protection of the Environment," Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan,"

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